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Using a Number of Environmental Factors to Determine the Water quality of the Tigris River at Wana, Nineveh, Iraq

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ABSTRACT
The current study included the use of phytoplankton as an indicator to assess the water quality of the Tigris River in the Wana district of Nineveh Governorate/ Iraq, Five sites were selected along the Tigris River, and samples were collected monthly from November 2021 to April 2022. Some environmental factors of water affecting water quality and its characteristics were studied including water temperature, which was suitable for drinking purposes throughout the study period. Its highest value did not exceed 23.8°C; while, the pH was within the permissible limits for drinking water, with values ranging between 7.0 & 8.1. The electrical conductivity recorded values within the normal range; its lowest value was 191 µS/cm, and the highest was 423 µS/cm. The dissolved oxygen results showed that the river water at all the sites under study was well aerated, The concentrations of nitrates and sulfates didn't exceed the limits allowed by the World Health Organization during the study period, as it recorded concentrations that ranged between 0.01-0.52 and 25-114mg/ L, respectively. For the phosphate concentrations in the river water, they had a medium to high effect with ranges between 0.08 & 1.6mg/ liter, and depending on the concentrations of total dissolved solids, the river water was somewhat fresh, The alkaline concentrations in the river water during the study period ranged between 74 &170mg/ l. The chloride ion concentration was wobbling, and the river water was classified as relatively hard to hard water. The total density of phytoplankton exceeded the threshold of half a million cell/ liter. Applied to a kind of biological indicator of pollution, Palmer's Poitution index (the index of species tolerant to pollution), showed that the water was possibly moderately polluted during the study period. At all sites under study, the value of the index in the first and fourth sites was (14), while the second site recorded the lowest value of the index, amounting to (13), while the value of the index was (15) in the third and fifth sites, during the study (43) species of algae were detected, in which Bacillus algae dominated.

INTRODUCTION

Water resources have been suffering over time from many physical, chemical and biological changes that are related to the state of the water body and the additions resulting from natural or human factors **(Ali & Al-Hadithi, 2018)**. The use of biological evidence is one of the useful and important methods for providing an explanation for the complex interaction between environmental factors and the extent of the organism's response and resistance to it since it reflects the environmental safety of water from the physical, chemical and biological aspects **(Kumar *et al*., 2012)**.

Algae have been used in many countries of the world to assess water quality and detect the existence or non- presence of pollution. They are known for their quick response to changes

that may occur in the physical and chemical factors of water sources. Thus, their appearance, intensity and absence depend on the living and non-living factors of the water **(Komala,*et al*., 2013)**.

Algae are known as autotrophic plants, with a simple composition containing the pigment chlorophyll a. There are types of algae that are found suspended or floating within the water column. Algae in aquatic ecosystems are of great importance ascribed to their role in the food chain, being an important food source for fish and aquatic animals **(Al-Nashy, 2016)**.

In recent years, most studies have tended to focus on studying the aquatic environment and its organisms including algae, which have been used as biological indicators of water quality. **Ismail and Saadallah (2010)** addressed the Diyala River in Iraq and elucidated that water temperature ranged between 20.1 & 31.3C˚, and the pH values were between 7.6 & 8.2. For the electrical conductivity, it reached 1160 microsiemens/ cm.The study identified (60) species of phytoplankton, and the diatoms dominated.

On the other hand, the study of **Hassan and Abdul-Amir (2014)** on the Tigris River in the city of Baghdad, Iraq identified (154) species of algae attached to the mud, in which diatoms were dominant, followed by blue-green algae and green algae, as diatoms formed 88.31%.

The researchers of **Al-Dulaimi and Khamis (2021)** and **AL-Aarajy *et al*. (2023)** conducted a diagnostic study of some types of algae in the Tigris River passing through the city of Al-Dhuluiya, Salah Al-Din and concluded that, water temperature reached the highest value (27.3) C˚, and the pH values were inclined toward the basal and ranged between 7.4 & 7.95, while the electrical conductivity values were between 145 & 651 microsiemens/cm . (97) types of algae were diagnosed at the stations under study, and diatoms constituted the overwhelming majority of them at a rate of 72.16%.

In addition, the study of **Shihab (2021)** reported some of the physical, chemical and biological properties of the Tigris River passing through the city of Mosul. The river water is classified as excellent to good according to its turbidity values, and the pH values are within the permissible limits in the drinking water specifications, as they fall within the range (6.5- 8.5). The results showed that the river water was well aerated, and the number of phytoplankton was related to water temperature, and the total number of them did not exceed 500,000 cell/ liter during the study period. **Mahmoud (2021)** during his study of phytoplankton at selected sites on the Tigris River in Nineveh Governorate identified (55) species of algae, and the total number of plankton ranged between 86702 & 834513 cell/ liter, and the number exceeded one million cell/liter twice between (45) Reading during his study period.

This study was organized to assess the water quality of the Tigris River at Wana district in the north of Nineveh Governorate, which is about 12km away from the Mosul Dam. The river is the vital artery on which the residents of the district depend for all agricultural and economic activities.

MATERIALS AND METHODS

The samples were taken from five sites along the course of the river passing within Wana district, as shown in Fig. (1) over a period of six months, starting from November 2021 till April 2022. Water samples were collected from the sites under study at the rate of 1sample/ site/ month, and measurements were determined following the methods mentioned in **APHA (2017)**.

Water temperature was measured using a mercury thermometer graded from 0- 100°C, whereas the pH was evaluated using a pH-meter. The electrical conductivity and total dissolved solids were measured using the TDS-C˚-meter- couductivity model YL-TDS2-A. They were measured based on the Winkler method zAzidemodifieation. Dissolved oxygen concentration was calculated by adding 2ml of a manganese sulfate solution and 2ml of a basic iodine solution to a specific volume of the sample, followed by adding 2ml of concentrated sulfuric acid. Afterwards, a known volume was taken from the sample and titration against a sodium thiosulfate solution. The standard water pentahydrate (0.025 N) and the dissolved oxygen concentration were calculated according to the following equation (DOmg/L=V.thio*N.thio*eq.wt*1000/ml of sample).

The concentration of nitrate ions was measured using the Ultra Violet Screening method by taking a volume from the sample, then adding 1ml of HCl (1N), and measuring it using a spectrophotometer at ultraviolet wavelengths of 220 and 275nm, with blank work to correct the readings, then finding the concentration from the standard curve in mg/L. On the other hand, the concentration of phosphate ions was measured using the Staunous Chlorid method using a known volume of the sample, adding drops of phenolphthalein index, then adding 4ml of ammonium molybdate and 10 drops of tinrose chloride. After 10- 12 minutes, the reading was determined using a spectrophotometer at a wavelength of 690nm, with make a blank, and the concentration was found from the standard curve in mg/L. While, the concentration of sulfate ions was estimated according to the Turbid matric method by taking a known volume of the sample, adding 1- 2ml of HCl (1:1), followed by an addition of crystals of barium chloride. Then, the outcome was measured using a spectrophotometer at a wavelength of 420nm making a blank. Hence, the concentration was detected from the standard curve in mg/L. On the other hand, the total alkalinity was measured by the titration of a known volume of the sample against a sulfuric acid solution of (0.02N) standard, using phenolphthalein and methyl orange indicators.

Via using the Mohar method, the concentration of chloride ions was measured by considering a known volume of the sample, adding drops of potassium chromate index and titrating against a standard silver nitrate solution (0.0141 N), according to the concentration from the following equation (Cl mg/L=(A-B)*N*35450/ml of sample). Additionally, the total hardness was measured based on the Na2EDTA titration method by taking a known volume of the sample, adding an appropriate amount of the buffer solution and a little Erichrom black -T indicator so that the color becomes purple, then titration was administered against the Na2EDTA solution until the blue color appeared, according to the concentration from the following equation (T.Hmg/LasCaCo3=V*N*eq.wt*1000/ ml of sample). For determining the total phytoplankton density, it was calculated following the method proposed by Mcmabb (1961), which includes filtration of a known volume of the sample by means of a Millipore filtration unit with the use of Millipore filter paper with fine pores (0.45 Mm), then the filter paper was lifted and left to dry, then it was placed on a clean glass slide and a drop of immersion oil was placed on top of it, a microscope mounted with an objective lens with a magnification of (40) times, then total count of phytoplankton cells present in (30) microscopic fields were randomly selected.

Afterwards, the total number of phytoplankton cells was calculated by applying the following equation (Total number of phytoplankton (cell / liter) = total cells in (30) microscopic fields *

area of the filter paper * 1000 / area of (30) microscopic fields *ml of sample). The vital Index was used by the Palmer coefficient of pollution (Algal Genus Pollution index)

A list containing (20) genera of algae was drawn up in Table (1), and a number for each genus ranging from (1-5) was given, determining the water quality of the sample when collecting points for the genera in the sample **(Palmer, 1969)**. The water quality in the sites under study was evaluated according to the Palmer pollution coefficient using the genera, as presented in Table (2).

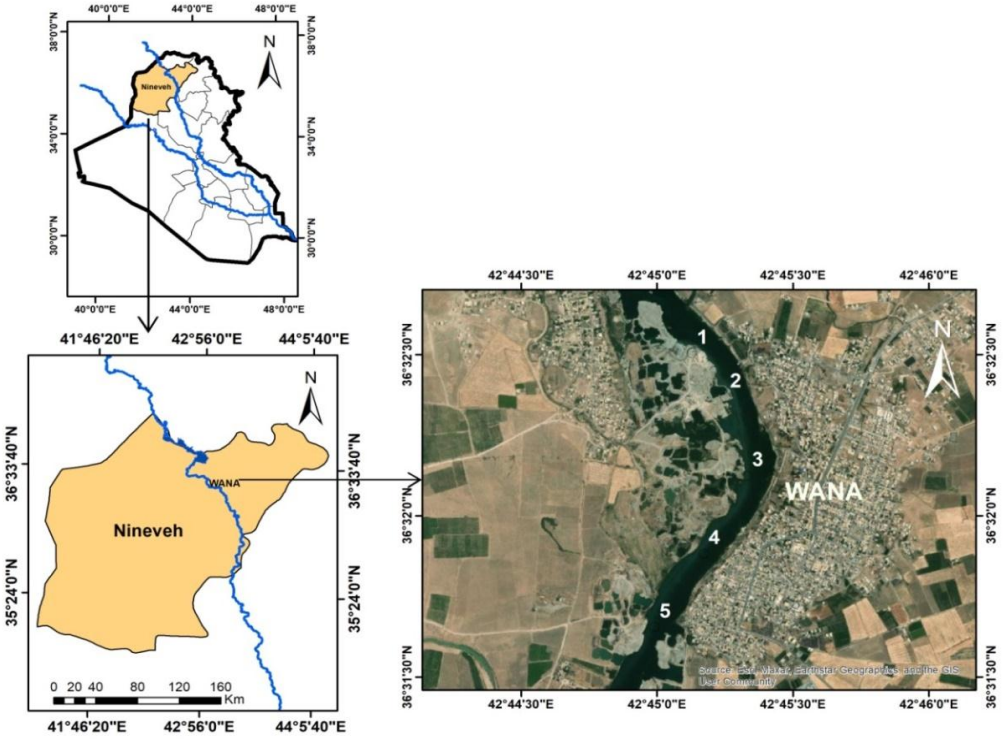

Figure (1): A map showing the sites under study(From Google Earth)

Table 1. Palmer's index of pollution using algae genera(Ali and Al-hadithy,2018)

Cenus	Score	Cenus	Score
Anacyctis	1	Micractinium	1
Ankistrodesmus	2	Naviculla	3
Chlamydomonas	4	Nitzschia	3
Chlorella	3	Oscillatoria	5
Closterium	1	Pandorina	1
Cyclotella	1	Phacus	2
Euglena	5	Phormidium	1
Gomphonema	1	Sceuedesmus	4
Lepocinclic	1	Stigeoclonium	2
Aulocosira	1	Synedra	2

Table 2. Classification of water quality according to the pollutant-tolerant genera index(Ali and Al-hadithy,2018)

Guide to polluting species	Water quality
0-10	No pollution
11-15	moderately polluted
16-20	Possibly a high level of pollution
21 and more	Confirmed contamination at a high level

RESULTS AND DISCUSSION

Table (3) shows the mean and the lower and upper limits of the physical, chemical and biological measurements of the sites under study. The water temperature ranged between 10 & 23.8ºC, and it is considered suitable for drinking, based on the specifications of the Federal Republic of Germany, which states that the highest temperature of the water of the streams prepared for filtration is 28ºC. The water temperature ranged between (10-23.8) C, and it is considered suitable for drinking, based on the specifications of the Federal Republic of Germany, which states that the highest temperature of the streams water prepared for filtration is 28ºC. These results agree with the findings of **Al-Obaidi (2013)**, **Al-Sarraj *et al*. (2014)** and **Al-Nuaimi (2017)** during their study on the Tigris River water in Nineveh Governorate. The water temperature recorded ranged between (9-25), (10-23) and (8.8-23) C, respectively; the temperature is one of the factors affecting the water quality, its physical and chemical properties, and the activity of microorganisms **(Al-Barzanji, 2020)**.

The pH recorded the highest value (8.1) for river water, with respect to the first and second sites, which is within the permissible limits for drinking water according to **Iraqi Standard Specifications (2001)** and the US Environmental Protection Agency **(EPA, 2012)** as it falls within the range (6.5-8.5). The results coincide with the outcomes of **Fadl and Hamid (2019)**, with pH values ranging between 6.5 & 8.4 and those of **Al-Dulaimi and Khamis (2021)**, recording pH values during their study of the Tigris River in Al-Dhuluiya between 7.4 & 7.95. The rise in pH values may be attributed to the photosynthesis activity carried out by algae and the consumption of CO_2, which leads to an increase in the formation of alkaline pathogens and that the pH values of the river water tend toward the basic in most months of the study due to the presence of bicarbonate ions **(Al-Maadidi, 2017)**. The value of electrical conductivity of river water in the sites under study ranged between 191 & 423 microsiemens/ cm, and the values were within the normal range set by the World Health Organization **(WHO, 2006)** between 0 & 1500 microsiemens/ cm. The present results of electrical conductivity vary from those reported in the studies of **Al-Sarraj (2013)** and **Al-Hadidi (2017)** recorded during their studies on the Tigris River water in Nineveh Governorate, as the values ranged between 331.5- 732 and 380-480 microsiemens/cm, respectively.

Table 3. Averages,minimum and maximum limits for the concentrations of the elements under study

environmental factor		St.1	St.2	St.3	St.4	St.5
water temperature	Max	21	23	23.5	23.8	23.8
	Min	10	10	11	10	11
	Mean	16.0	15.7	16	16.8	16.8
pH	Max	8.1	8.1	8.0	7.9	7.8
	Min	7.0	7.5	7.5	7.4	7.5
	Mean	7.7	7.8	7.7	7.6	7.6
conductivity (microsiemens/cm)	Max	374	382	368	423	421
	Min	289	314	191	251	289
	Mean	342	346	312	336	355
dissolved oxygen (mg/L)	Max	15	14	18	15.6	16
	Min	6	5.6	5.2	5.8	6
	Mean	11	10.2	10.7	9.6	10.9
nitrates (mg/L)	Max	0.46	0.46	0.45	0.5	0.52
	Min	0.03	0.01	0.05	0.02	0.02
	Mean	0.16	0.19	0.18	0.18	0.23
phosphates (mg/L)	Max	1.1	1.6	1.1	0.91	1.6
	Min	0.08	0.09	0.14	0.09	0.1
	Mean	0.50	0.62	0.5	0.48	0.74
Sulfites (mg/L)	Max	١١٤	104	110	109	114
	Min	35.4	43	46.5	26	25
	Mean	90.3	71.2	79.1	70.5	77
Total dissolved solids (mg/L)	Max	176	180	173	199	198
	Min	100	148	90	150	136
	Mean	161	165	148	150	170
Total Alkalinity (mg/L)	Max	170	150	150	154	148
	Min	80	80	82	74	82
	Mean	107	96	98	95	96
Chloride (mg/L)	Max	20.9	20.9	14.9	25.9	17.9
	Min	5.9	4.9	4.9	5.9	4.9
	Mean	15.4	14.9	11.6	15	12.9
Total hardness (mg/L as caco3)	Max	225	200	200	205	175
	Min	105	95	115	125	135
	Mean	148	145	161	162	153
Total phytoplankton density (cells/litre)	Max	426291	455192	404615	419066	534670
	Min	180632	155343	180631	162569	177019
	Mean	335912	305869	296838	288409	335373

The reason for the continuous differences in electrical conductivity values may be attributed to the presence of dissolved materials through the successive outfalls that flow into the river, as well as the effect of water temperature and the role of the processes of self-purification, sedimentation, propagation of plants and their absorption of nutrients **(Al-Taie, 2012; Abdel-Hafez & Thomas, 2019)**. Table (3) shows that the dissolved oxygen concentrations ranged between 5.2 & 18mg/ l, and that the water in all the sites under study is well aerated; this may be due to the aeration process resulting from the rapid flow of the river and the effect of the photosynthesis process carried out by plants and aquatic phytoplankton, which leads to high concentrations of dissolved oxygen in the water, and is almost identical in its rates to the

international values mentioned in **WHO (2006)**. It is worth noting that, the inverse relationship between temperature, salinity and dissolved oxygen was clear during the current study period. This relationship was confirmed in the studies of **Cole (1979)**, **Hammer *et al.* (2004)**, **Al-Watar (2009)** and **Al-Sarraj (2013)** addressing the Tigris River water in Nineveh Governorate. The concentrations of nitrates in the river water recorded the lowest values (0.01) mg/L at the second site, and this may be due to consumption by algae present in this site. As for the highest value, it amounted to reach 0.52mg/ L, which is higher than what was recorded by **Al-Sangary (2001)** and **Shihab (2021)**, who recorded values of 0.38 and 0.18mg/ L, respectively, without exceeding the permissible limits recommended by the World Health Organization (10mg/ L). For the phosphate concentrations, it ranged between 0.08 & 1.6mg/ L, and this may be related to the large number of its sources through the waste of laundry and cleaning activities, phosphate fertilizers, among others **(Sernaand Bergwitz, 2020)**. Based on the classification of **Water watch (1997)**, the river water is classified in relation to the phosphate concentration during the study period as medium to high impact in all the sites under study. The results of the study concur with those of **Al-Mashhadani (2019)** who found that, the phosphate concentration amounted to 0.77mg/ L upon studying the environmental reality of the Tigris River water . The values of sulfate concentration in river water during the study period ranged between 25 & 114mg/ L, which is within the permissible limits set by the World Health Organization **(WHO, 2017)** of 250mg/ L. The variation in the values of sulfates was noticed, for instance, **Al-Sarraj (2013)** mentioned that the range ranged between 28 & 80mg/ l, while **Al-Hadidi (2017)** concluded that, the range fell between 49 & 155mg/ L, and **Ibrahim (2022)** recorded values between 88.4 & 130.1mg/ L during their study on the river water in Nineveh Governorate. The reason for this may be due to the concentrations of organic pollutants resulting from human activities that reach the river water through estuaries, as well as the river's passage through agricultural lands in which fertilizers containing sulfates are used, drifted with water from agricultural lands to the river, especially in the rainy season..

The results of the current study (Table 3) indicate that, the river water at all the sites under study was fresh, depending on the concentration of total dissolved solids, which ranged between 90 & 99mg/ L. According to the classification of **Davis and Ddewiest (1966)**, the spatial and temporal changes in the values of dissolved solids in the Tigris River water are attributed to the influence of the river water on weather factors and the components of the earth's crust, as well as the disposal of industrial and domestic waste water to the river **(Al-Asadi, 2006)**.

It was noted through the results of the current study that there is a positive relationship between each of the electrical conductivity and total dissolved solids, and that this relationship has been observed by many researchers, including **Abowei (2010)** and **Al-Saadi (2014)**. This happens because its values depend on the presence of positive and negative ions in water **(Abid & Harikrishna, 2008)**.

The total alkaline concentrations in the river water during the study period were between 74 & 170mg/ L, and the variation in the total alkalinity values may be attributed to the significant influence of the appropriate water on the alkalinity values, as well as the variation in the hydrology of the water **(Smith, 2004)**.

In addition, the results showed that the concentrations of chloride ion during the study period were fluctuating, as the lowest value (4.9) mg/L was recorded in November 2021 at the second,

third and fifth sites under study, while the highest value of chloride ion was recorded in the water of the fourth site during April 2022. It reached 25.9mg/ L. These results are similar to what was recorded by **Al-Mashhadani (2019)** and **Ibrahim (2022)** in their study of the Tigris River, as they found that the highest value of chloride ion in the river water was 28mg/ L. It is worthy to mention that, chloride ions are characterized by their high ability to dissolve in water **(Al-Bihar, 2021; Najeeb & Saeed,2022).**

The values of the total hardness of the river water regarding the sites under study ranged between 95 & 225mg/ L as $Caco_{3,}$ which is within the permissible limits by the world health organization. The river water is classified as relatively hard water to hard water within the classification of **Todd and Mays (2005)**. This may be attributed to the increase in the precipitation of calcium carbonate by temperature, as well as the role of the river's own technical process .

The results of phytoplankton obtained during the study period indicate that the total number exceeded the threshold of half a million cell/ liter, as it reached the largest number (534,670) cell/ liter observed in November 2021 at the fifth site. The monthly changes were clear and showed a directly relation with water temperature, as shown in Fig. (2). No clear explanation was given for the changes in the number of phytoplankton, which might be attributed to the influence of their growth by measured and unmeasured environmental factors, as well as the interaction of these factors with each other. These results differ from those reported in the study of **Al-Nuaimi (2017)** on the Tigris River water in Nineveh Governorate, as the number of phytoplankton did not exceed the threshold of half a million cells/liter and reached 411801.2 cell/liter.

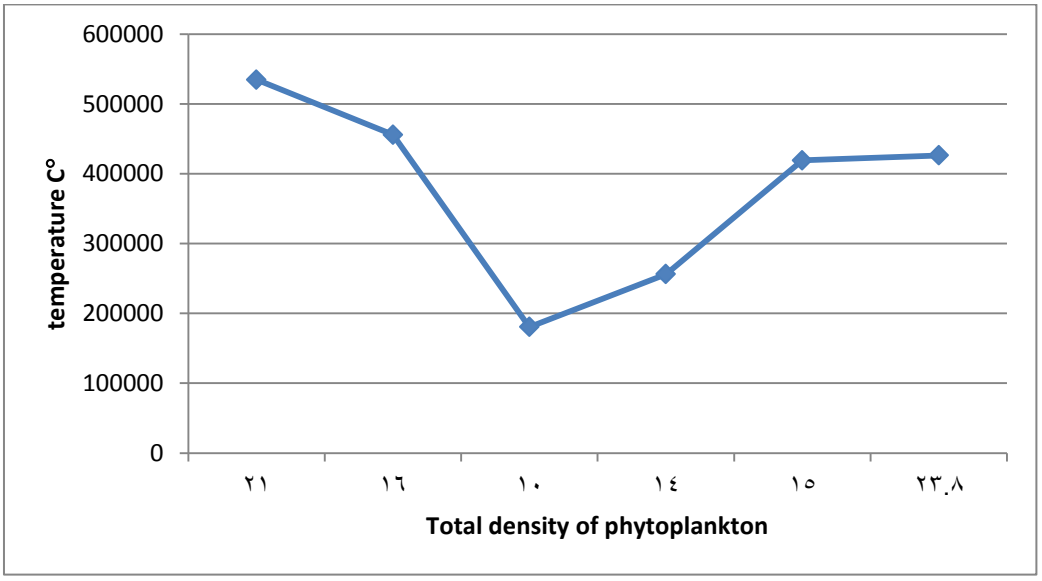

Figure 2. The relationship between water temperature and the total density of phytoplankton

The number of algae species that were diagnosed during the current study period reached 43 species, and it was noted that, Bacillarophycophyta was superior to the rest of the algae, as it constituted 72.09%, while the rest of the totals constituted only about a quarter of the total number of recorded species, And that the phenomenon of the superiority of diatomaceous algae over the rest of the species has been proven by many researchers in Iraqi water **(Hassan *et al*.,**

2010; Salman *et al*., 2013; Ibrahim, 2020; Mahmoud, 2021). It was followed by the Chlorophycophyta (13.95%), the Cyanophycophyta (9.30%) and Euglenophycophyta algae (4.65%), as shown in Fig. (3). **Graneli and Turner (2006)** postulated that, the use of blue-green algae, Euglena algae and some bacillus algae as an indicator of pollution is a common biological method in many countries of the world.

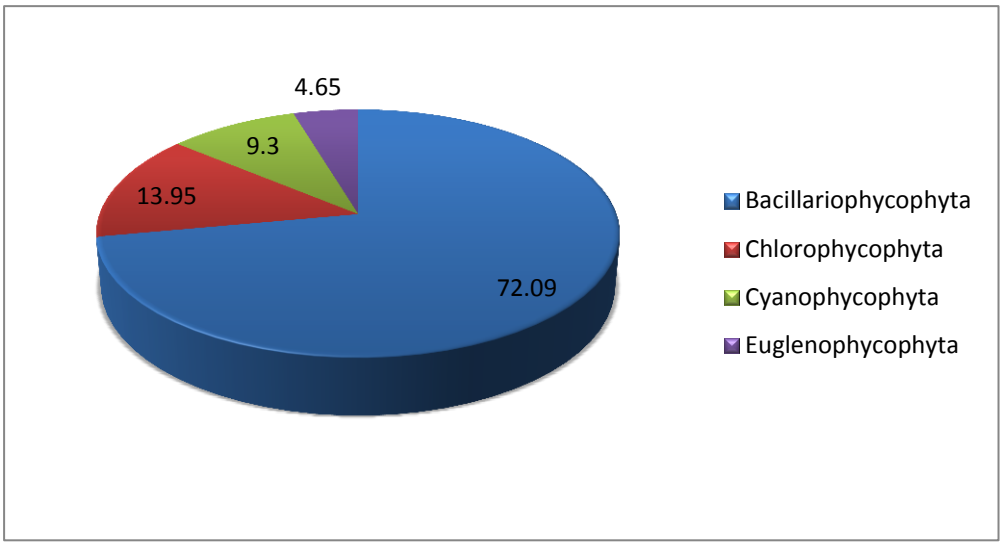

Figure 3. Percentages of algae species in the sites under study

This is because many of these algae resort to saprotrophic feeding during hard environmental conditions, in addition to the fact that the presence of the genus Oscillatoria is evidence of high-level organic pollution **(Sahin *et al*., 2010)**.

The algae genera Nitzschia,Cymbella, Cocconeis, Melosira were observed at all sites during the current study period, while the genus Naviculla appeared at all sites under study except for the fifth site, and the genus Synedra appeared at the first, second and third sites; whereas, the genus Cyclotella was present at the first and fourth sites. The genus Scenedesmus appeared at the first, second and third sites during the study period. The genus Chlorella was observed at the first, second and third sites, while the genus Oscillatoria was only observed at the fourth and fifth sites throughout the study period. The fifth site recorded the highest density of algae in November 2021, coinciding with the availability of optimal environmental conditions represented by the appropriate temperature and abundance of nutrients, Accompanied by the small number of species, which confirms its contamination with sewage water, the appearance of the genus Euglena was limited to the second and fifth sites within the period of the current study. This study is consistent with what was reached by **Mahmoud (2021)** as diatoms constituted 74.54% during his study of the Tigris River water in Nineveh Governorate. **Abdul-Jabar *et al*. (2018)**, in their study of the quality and quantity of diatomaceous attaching to the mud in the Tigris River that passes through Wasit Governorate found a predominance and abundance of diatomaceous algae by 99%. In general, the predominance of diatoms in the local inland water may be due to their containing quantities of silica. Additionally, the dominance of diatoms throughout the months of the study may be due to the diatoms, after their death, keeping the wire wall maintaining its shape and texture and are not subject to decomposition,

thus the diatoms appear present even if they have dead cells **(Alaarajy *et al*., 2023)**.

For the pollutant-tolerant genera index (Palmer's Pollution index), the results showed that the water of the first and second sites are possibly moderately polluted, as the values of the index were recorded with values of 14 and 13, respectively, while the third and fourth sites under study recorded an index value of 15 and 14; their water was classified as moderately polluted. While, the fifth site recorded the highest number of the genera that have high degrees within the Palmer classification, including Oscillatoria and Euglena, and thus the value of the evidence appeared in it, amounting to 15. Its water was classified as moderately polluted, according to the index of species that bear pollution (Palmer's Pollution index).

Table 4. Algae species recorded during the study and the sites where they appeared

Algae species	Site 1	Site 2	Site 3	Site 4	Site 5
Bacillario phyceae					
Naviculla cryptocephala	+	+	+	+	
Naviculla tripunctata		+	+		
Naviculla Pere grine	+	+			
Naviculla capitate	+	+	+	+	
Naviculla arvensis	+	+		+	
Naviculla pseudotuscula	+	+	+	+	
Naviculla ramosissma			+	+	
Naviculla halophila	+				
Nitzschia obtus		+	+		
Nitzschia Sigmoidae				+	+
Nitzschia trybionella	+			+	
Naviculla cubtillissima					+
Naviculla Canalis		+		+	+
Cymbella tumida			+		
Cymbella Cistula				+	+
Cymbella turgida		+			+
Cymbella offinis	+		+	+	
Cymbella cymbiformis		+	+	+	
Cyclotella meneghiniana	+				
Cyclotella Ocelata				+	
Cocconeis rugosa	+	+		+	+
Cocconeis Placentula		+			
Cocconeis Pediculus	+		+	+	
Cocconeis disculus	+	+			
Synedra acus			+		
Synedra ulna			+	+	
Synedra radians				+	
Synedra fasiculata					+
Melosira varians	+	+			
Melosira granulate	+		+		
Melosira arctica		+		+	+
Chlorophyco phyceae					
Chlorella vulgaris	+	+	+		
Chlorella lleposide			+		
Scenedesmus abundans	+		+		
Scenedesmus arcuatus	+				
Scenedesmus quadricanda		+	+		

Scenedesmus bijuge	+				
Cyanophycophy ceae					
Oscillatoria Prolifica				+	+
Oscillatoria nigra				+	
Oscillatoria Splendida					+
Oscillatoria tenuis				+	+
Eugleno phycophy ceae					
Euglena proxima					+
Euglena convoluta		+			

Table 5: show the relationship between the elements under study

	Temp.	**pH**	**E.C**	**DO**	**NO_3^-**	**PO_4^-**	**SO_4^-**	**TDS**	**T.Alk.**	**Cl^-**	**T.H.**	**Phytoplankton Density**
Temp.	1	-0.965	0.284	-0.241	0.506	0.229	-0.263	0.003	-0.391	-0.09	0.5	0.023
pH		1	-0.125	0.093	-0.369	-0.086	0.049	0.119	0.206	0.175	-0.637	-0.07
E.C			1	0.080	0.502	0.697	-0.06	0.88	-0.026	0.51	-0.632	0.62
DO				1	0.132	0.329	0.794	0.429	0.615	-0.367	-0.37	0.809
NO_3^-					1	0.912	-0.422	0.586	-0.619	-0.427	-0.015	0.267
PO_4^-						1	-0.219	0.853	-0.364	-0.223	-0.419	0.530
SO_4^-							1	0.091	0.949	0.03	-0.265	0.673
TDS								1	0.61	0.216	-0.782	0.772
T.Alk.									1	0.312	-0.385	0.577
Cl^-										1	-0.487	0.105
T.H.											1	-0.607
Phytoplankton Density												1

CONCLUSION

The research focused on the evaluating the Tigris river water quality at Wana district, depending on a number of environmental factors and Palmer's index of pollution using algae genera. The study showed that the values of all the parameters under study were within the drinking water standards proposed by the World Health Organization and Iraqi standards of 2019. Then, exposure to the rainy season was addressed which leads to an increase in some parameters of pollution. Finally, the study concluded that the river water must be subject to treatment before being used for drinking purposes.

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